

FORM PTO-1390 (REV. 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 270/177
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. <small>If known, see 37 CFR 1.5</small> 10/031983
INTERNATIONAL APPLICATION NO. PCT/EP00/06931	INTERNATIONAL FILING DATE July 20, 2000	PRIORITY DATE CLAIMED July 28, 1999
TITLE OF INVENTION AMINE HARDENER FOR EPOXY RESINS		
APPLICANT(S) FOR DO/EO/US Walter FISCHER; Claudio A. GABUTTI; Isabelle FRISCHINGER; Rolf WIESENDANGER		
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:		
<p>1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.</p> <p>2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.</p> <p>3. <input type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.</p> <p>4. <input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31).</p> <p>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))</p> <ul style="list-style-type: none"> a. <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau) b. <input checked="" type="checkbox"/> has been communicated by the International Bureau c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). <p>6. <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).</p> <ul style="list-style-type: none"> a. <input checked="" type="checkbox"/> is attached hereto. b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4) <p>7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))</p> <ul style="list-style-type: none"> a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input checked="" type="checkbox"/> have not been made and will not be made. <p>8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</p> <p>9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</p> <p>10. <input type="checkbox"/> An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</p>		
Items 11 to 20 below concern document(s) or information included:		
<p>11. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</p> <p>12. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</p> <p>13. <input type="checkbox"/> A FIRST preliminary amendment.</p> <p>14. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.</p> <p>15. <input type="checkbox"/> A substitute specification.</p> <p>16. <input type="checkbox"/> A change of power of attorney and/or address letter.</p> <p>17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 – 1.825.</p> <p>18. <input checked="" type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4).</p> <p>19. <input checked="" type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).</p> <p>20. <input checked="" type="checkbox"/> Other items or information: PCT/IB/308</p>		

U.S. APPLICATION NO. (if known, see 37 CFR 1.45)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER	
10/051983	PCT/EP00/06931	270/177	
21. <input checked="" type="checkbox"/> The following fees are submitted:		CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492(a)(1) – (5)):			
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1040.00			
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$890.00			
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$740.00			
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$710.00			
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00			
ENTER APPROPRIATE BASIC FEE AMOUNT =			
\$890.00			
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).			
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	15 - 20 =	0	x \$18.00
Independent claims	5 - 3 =	2	x \$80.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		+ \$270.00	\$270.00
TOTAL OF ABOVE CALCULATIONS = \$1320.00			
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by $\frac{1}{2}$. + SUBTOTAL = \$1320.00			
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)). TOTAL NATIONAL FEE = \$1320.00			
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property + TOTAL FEES ENCLOSED = \$1360.00			
Amount to be refunded: \$			
Charged: \$			
<p>a. <input type="checkbox"/> A check in the amount of \$ to cover the above fees is enclosed.</p> <p>b. <input checked="" type="checkbox"/> Please charge my Deposit Account No. 12-2475 in the amount of \$1360.00 to cover the above fees. A duplicate copy of this sheet is enclosed.</p> <p>c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 12-2475. A duplicate copy of this sheet is enclosed.</p> <p>d. <input type="checkbox"/> Fees are to be charged to a credit card. WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.</p>			
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.			
SEND ALL CORRESPONDENCE TO: KRISTIN H. NEUMAN, ESQ. LYON & LYON, LLP SUITE 4700 633 WEST FIFTH STREET LOS ANGELES, CA 90071		 SIGNATURE NAME KRISTIN H. NEUMAN, ESQ. REGISTRATION NUMBER 35,530	

10/031983

531 Rec'd PCT/US 25 JAN 2002

CERTIFICATE OF MAILING
(37 C.F.R. §1.10)

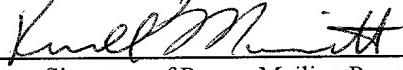
I hereby certify that this paper (along with any referred to as being attached or enclosed) is being deposited with the United States Postal Service on the date shown below with sufficient postage as 'Express Mail Post Office To Addressee' in an envelope addressed to Box PCT, Commissioner for Patents, Washington, D.C. 20231.

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Russell Morrisette

Name of Person Mailing Paper



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Amine hardener for epoxy resins

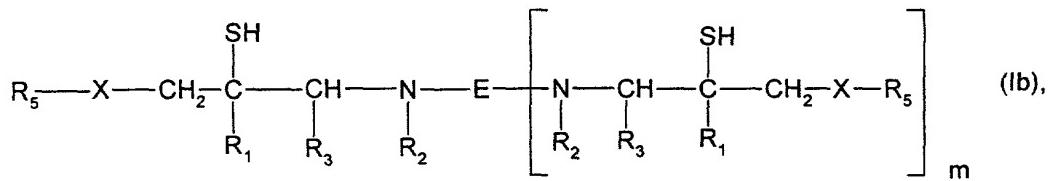
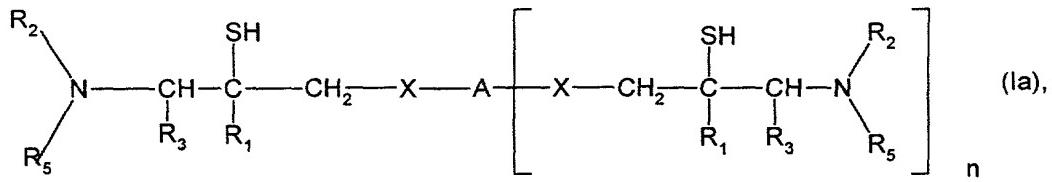
The present invention relates to polymercaptopolyamines, to a process for the preparation thereof, to epoxy resin compositions comprising such polymercaptopolyamines and to the use of those compositions.

U.S. Patent No. 5 143 999 describes mixtures of polyamines and of dithiols derived from polyoxyalkylene glycols as hardeners for epoxy resins. The cured products produced therefrom are distinguished by a high degree of flexibility and good viscoelastic properties combined with good strength and hardness values.

The problem of the present invention was to provide curing agents for epoxy resins which yield cured products having improved resistance to chemicals.

It has now been found that certain polymercaptopolyamines are highly reactive with respect to epoxy resins even at low temperatures and that the cured products obtained therefrom have both improved resistance to chemicals and increased resistance to weathering.

The present invention relates to compounds of formula Ia or Ib,



wherein A is an $(n + 1)$ -valent aliphatic, cycloaliphatic, araliphatic or aromatic radical and n is an integer from 0 to 5,

E is an $(m + 1)$ -valent aliphatic, cycloaliphatic, araliphatic or aromatic radical and m is an integer from 0 to 3,

X is -O-, -COO- or -CHR₄-, with R₄ and R₃ together forming an ethylene group,

R_1 and R_2 are, each independently of the other, hydrogen or methyl,
 R_3 is hydrogen, or R_3 and R_4 together form an ethylene group,
and R_5 is a monovalent aliphatic, cycloaliphatic, araliphatic or aromatic radical.

In formula Ia, A can, in principle, be any mono- to hexa-valent epoxy radical. Preference is given to bi-, tri- and tetra-valent radicals.

Examples of aliphatic radicals are ethylene, propylene, tetramethylene, hexamethylene, poly(oxyethylene), poly(oxypropylene), poly(oxytetramethylene), 2-methyl-1,5-pentanediyl, 2,2,4-trimethyl-1,6-hexanediyl, 2,4,4-trimethyl-1,6-hexanediyl and the radicals of aliphatic alcohols after removal of the OH groups, for example the radicals of trimethylolpropane, pentaerythritol and dipentaerythritol.

Cycloaliphatic radicals are, for example, cyclopentyl, cyclohexyl, 1,3-cyclopentylene, 4-methyl-1,3-cyclopentylene, 1,2-cyclohexylene, 1,3-cyclohexylene, 1,4-cyclohexylene, 4-methyl-1,3-cyclohexylene, 2,5-norbornanediyl, 2,6-norbornanediyl, 7,7-dimethyl-2,5-norbornanediyl, 7,7-dimethyl-2,6-norbornanediyl, cyclohexane-1,3-dimethylene, cyclohexane-1,4-dimethylene, 3-methylene-3,5,5-trimethylcyclohexylene (isophorone), norbornane-2,5-dimethylene, norbornane-2,6-dimethylene, 7,7-dimethylnorbornane-2,5-dimethylene and 7,7-dimethylnorbornane-2,6-dimethylene and the radicals of cycloaliphatic alcohols after removal of the OH groups, for example the radicals of hydrogenated bisphenol A and hydrogenated bisphenol F.

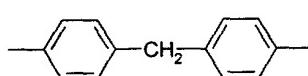
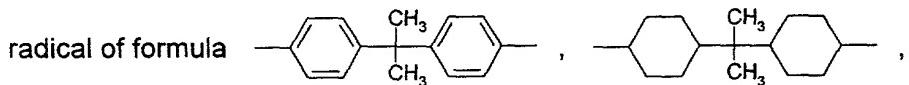
Suitable araliphatic radicals are, for example, benzyl, the radicals of 1,2-, 1,3- and 1,4-bis(hydroxymethyl)benzene, the radicals of 1,2,3-, 1,2,4-, 1,2,5- and 1,3,5-tris(hydroxymethyl)benzene and the radicals of bis(hydroxymethyl)naphthalene. Examples of aromatic radicals are phenyl, naphthyl, the radicals of bisphenols, for example bisphenol A, bisphenol F and dihydroxybiphenyl, and the radicals of phenol novolaks and cresol novolaks.

Preference is given to compounds of formula Ia wherein X is -O- and A is a bivalent radical of a bisphenol or of a cycloaliphatic diol, the radical of a phenol novolak or cresol novolak,

the bi- to tetra-valent radical of an isocyanate/polyol adduct or the tri- to hexa-valent radical of a tri- to hexa-functional aliphatic polyol.

Special preference is given to compounds of formula Ia wherein X is -O- and A is a bivalent

radical of formula

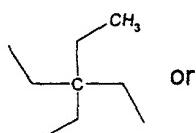


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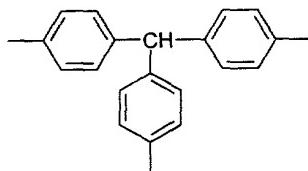


, the radical of a

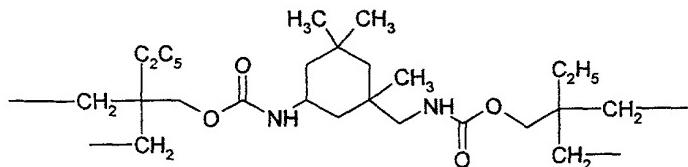
phenol novolak or cresol novolak, a trivalent radical of formula



or



or the tetravalent radical of formula



R₅ in formulae Ia and Ib is preferably C₁-C₂₀alkyl, C₅-C₁₂cycloalkyl, C₆-C₁₀aryl or C₇-C₁₂aralkyl, each of which is unsubstituted or substituted by one or more amino groups, hydroxyl groups, C₁-C₆alkoxy groups or halogen atoms.

Alkyl groups that are suitable as R₅ are, for example, methyl, ethyl, isopropyl, n-propyl, n-butyl, isobutyl, sec-butyl, tert-butyl and the various isomers of pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl and octadecyl groups.

Cycloalkyl is preferably C₅-C₈cycloalkyl, especially C₅- or C₆-cycloalkyl. Examples include cyclopentyl, methylcyclopentyl, cyclohexyl, cycloheptyl and cyclooctyl.

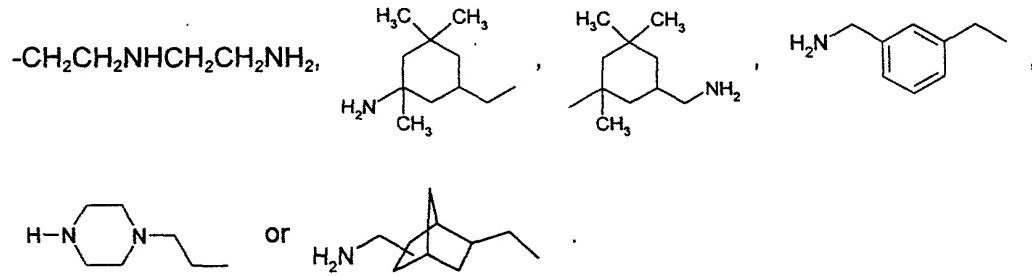
Aralkyl contains preferably from 7 to 12 carbon atoms and especially from 7 to 10 carbon atoms and may be, for example, benzyl, phenethyl, 3-phenylpropyl, α -methylbenzyl, 4-phenylbutyl and α,α -dimethylbenzyl.

Aryl groups are, for example, phenyl, tolyl, mesityl, isityl, naphthyl and anthryl.

Preference is given to compounds of formulae Ia and Ib wherein R₅ is C₂-C₁₀alkyl, C₂-C₁₀aminoalkyl, phenyl, benzyl, cyclohexyl or a radical of formula H₂N-Z-CH₂-NH-, wherein Z is a bivalent cycloaliphatic, araliphatic or aromatic radical or a radical of formula -(CH₂CH₂NH)_k-CH₂-, wherein k is 2 or 3.

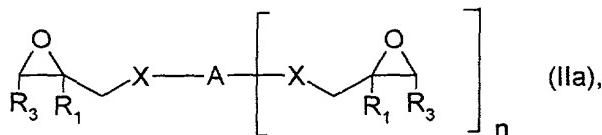
Suitable radicals Z are, for example, the bivalent radicals mentioned for A hereinbefore.

Special preference is given to compounds of formulae Ia and Ib wherein R₁ is n-butyl, n-octyl, cyclohexyl, benzyl, 2-aminoethyl, 4-(aminomethyl)pentyl, 5-amino-2-methylpentyl, 3-dimethylaminopropyl, 3-methylaminopropyl, 4-aminocyclohexyl or a radical of formula



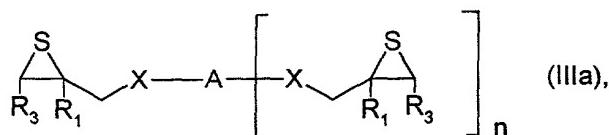
Preference is given also to compounds of formula Ia or Ib wherein X is O- and R₁ and R₃ are hydrogen.

The compounds of formula Ia can be prepared in accordance with known methods from the epoxy compounds of formula IIa:



wherein A, X, R₁, R₃ and n are as defined hereinbefore.

In such methods, the epoxy compound of formula IIa is, in a first reaction step, converted by reaction with thiourea or an alkali-metal or ammonium thiocyanate, preferably potassium thiocyanate, into the episulfide of formula IIIa



the thiourea or thiocyanate advantageously being used in an amount such that there are from 0.8 to 1.2 equivalents of sulfur for one epoxy equivalent.

The reaction can be carried out in aprotic or protic organic solvents or mixtures thereof. Preference is given to alcohols, for example methanol and ethanol, and aromatic hydrocarbons, for example toluene and xylene. The addition of co-solvents, for example ethers or carboxylic acids, can speed up the reaction.

The reaction can be carried out at room temperature and also at elevated temperature; the preferred reaction temperature is from 60 to 100°C.

The episulfide of formula IIIa can be isolated by separating off the by-products by means of filtration, extraction, phase separation and subsequent concentration by evaporating off the solvent.

It is also possible, however, for the episulfide of formula IIIa to be further processed directly, in the form of the crude product in solution, without separating off the by-products.

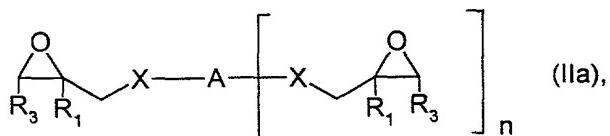
The episulfide of formula IIIa is then dissolved in an aprotic or protic organic solvent and, under inert gas (argon or nitrogen), reacted with the amine R₅-NH-R₂, the amount of the amine preferably being so selected that there are from 1 to 10 NH groups for one episulfide group. Preferred solvents are alcohols (e.g. methanol, ethanol, tert-butanol) and aromatic hydrocarbons, for example toluene and xylene.

Preferably, the amine R_1-NH_2 is also used in the form of a solution in one of the above-mentioned organic solvents.

The reaction is advantageously carried out at elevated temperature, preferably at from 40°C to 120°C.

The compounds of formula Ia according to the invention can be isolated by distilling off the solvent under reduced pressure. The excess amine R_5-NH-R_2 can then likewise be removed by distillation at elevated temperature. In a particular embodiment of the invention, the amine R_5-NH-R_2 is used as co-hardener, in which case separation of the product of formula Ia and the amine R_5-NH-R_2 is not necessary; rather, the reaction product can be used as a hardener for epoxy resins without further working-up. That procedure is recommended especially when using di- or poly-amines.

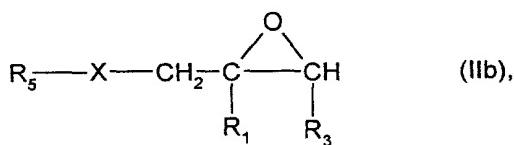
The present invention accordingly relates also to a process for the preparation of compounds of formula Ia by reacting a compound of formula IIa



wherein A, X, R_1 , R_3 and n are as defined hereinbefore,
with thiourea or a thiocyanate and subsequently reacting the resulting episulfide with an amine of formula R_5-NH-R_2 wherein R_5 and R_2 are as defined hereinbefore.

The compounds of formula Ib can be prepared analogously from the corresponding epoxy compounds of formula IIb.

The invention accordingly relates further to a process for the preparation of compounds of formula Ib by reacting a compound of formula IIb



wherein X, R_1 , R_3 and R_5 are as defined hereinbefore,

with thiourea or a thiocyanate and subsequently reacting the resulting episulfide with a polyamine of formula E-(NHR₂)_{m+1} wherein E, R₂ and m are as defined hereinbefore.

Episulfides can, for example, also be synthesised from the corresponding epoxides by reaction with triphenylphosphine sulfide.

In addition, episulfides can be prepared according to known methods directly from the corresponding alkenes, for example by reaction with m-chloroperbenzoic acid and subsequent reaction with thiourea in the presence of H₂SO₄, by reaction with propylene sulfide in the presence of rhodium catalysts and also by reaction with (diethoxyphosphoryl)sulfenyl chloride, (diethoxythiophosphoryl)sulfenyl bromide, thiobenzophenone S-oxide or bis(trimethylsilyl) sulfide.

As mentioned initially, the polymermercaptopolyamines according to the invention are especially suitable as hardeners for epoxy resins.

The invention relates further to a composition comprising

- (A) an epoxy resin having, on average, more than one 1,2-epoxy group per molecule, and
- (B) a compound of formula Ia or Ib.

For preparation of the compositions according to the invention, the epoxy resins customary in epoxy resin technology are suitable as component A. Examples of epoxy resins are:

I) polyglycidyl and poly(β-methylglycidyl) esters, obtainable by reacting a compound having at least two carboxyl groups in the molecule with epichlorohydrin and β-methyl-epichlorohydrin, respectively. The reaction is advantageously carried out in the presence of bases.

Aliphatic polycarboxylic acids may be used as the compound having at least two carboxyl groups in the molecule. Examples of such polycarboxylic acids are oxalic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid and dimerised or trimerised linoleic acid.

However, cycloaliphatic polycarboxylic acids may also be used, for example tetrahydro-phthalic acid, 4-methyltetrahydrophthalic acid, hexahydrophthalic acid or 4-methylhexahydro-phthalic acid.

Aromatic polycarboxylic acids may also be used, for example phthalic acid, isophthalic acid and terephthalic acid.

II) Polyglycidyl or poly(β -methylglycidyl) ethers, obtainable by reacting a compound having at least two free alcoholic hydroxy groups and/or phenolic hydroxy groups with epichlorohydrin or β -methylepichlorohydrin under alkaline conditions, or in the presence of an acid catalyst and subsequently treating with an alkali.

The glycidyl ethers of this kind are derived, for example, from acyclic alcohols, e.g. ethylene glycol, diethylene glycol and higher poly(oxyethylene) glycols, propane-1,2-diol or poly(oxypropylene) glycols, propane-1,3-diol, butane-1,4-diol, poly(oxytetramethylene) glycols, pentane-1,5-diol, hexane-1,6-diol, hexane-2,4,6-triol, glycerol, 1,1,1-trimethylol-propane, pentaerythritol, sorbitol and also from polyepichlorohydrins.

Further glycidyl ethers of this kind are derived from cycloaliphatic alcohols, e.g. 1,4-cyclohexanedimethanol, bis(4-hydroxycyclohexyl)methane or 2,2-bis(4-hydroxycyclohexyl)-propane, or from alcohols that contain aromatic groups and/or further functional groups, e.g. N,N-bis(2-hydroxyethyl)aniline or p,p'-bis(2-hydroxyethylamino)diphenylmethane.

The glycidyl ethers can also be based on mononuclear phenols, such as resorcinol or hydroquinone, or on polynuclear phenols, such as bis(4-hydroxyphenyl)methane, 4,4'-dihydroxybiphenyl, bis(4-hydroxyphenyl)sulfone, 1,1,2,2-tetrakis(4-hydroxyphenyl)ethane, 2,2-bis(4-hydroxyphenyl)propane or 2,2-bis(3,5-dibromo-4-hydroxyphenyl)propane.

Further hydroxy compounds that are suitable for the preparation of glycidyl ethers are novolaks, obtainable by condensing aldehydes, e.g. formaldehyde, acetaldehyde, chloral or furfuraldehyde, with phenols or bisphenols that are unsubstituted or substituted by chlorine atoms or by C₁-C₅alkyl groups, e.g. phenol, 4-chlorophenol, 2-methylphenol or 4-tert-butylphenol.

III) Poly(N-glycidyl) compounds, obtainable by dehydrochlorination of the reaction products of epichlorohydrin with amines containing at least two amine hydrogen atoms. Such amines

are, for example, aniline, n-butylamine, bis(4-aminophenyl)methane, m-xylylenediamine or bis(4-methylaminophenyl)methane.

The poly(N-glycidyl) compounds also include, however, triglycidyl isocyanurate, N,N'-diglycidyl derivatives of cycloalkylene ureas, e.g. ethylene urea or 1,3-propylene urea, and diglycidyl derivatives of hydantoins, e.g. 5,5-dimethylhydantoin.

IV) Poly(S-glycidyl) compounds, such as di-S-glycidyl derivatives derived from dithiols, e.g. ethane-1,2-dithiol or bis(4-mercaptomethylphenyl) ether.

V) Cycloaliphatic epoxy resins, e.g. bis(2,3-epoxycyclopentyl) ether, 2,3-epoxycyclopentylglycidyl ether, 1,2-bis(2,3-epoxycyclopentyloxy)ethane or 3,4-epoxycyclohexylmethyl 3',4'-epoxycyclohexanecarboxylate.

It is also possible, however, to use epoxy resins wherein the 1,2-epoxy groups are bound to different hetero atoms or functional groups; such compounds include, for example, the N,N,O-triglycidyl derivative of 4-aminophenol, the glycidyl ether-glycidyl ester of salicylic acid, N-glycidyl-N'-(2-glycidyloxypropyl)-5,5-dimethylhydantoin and 2-glycidyloxy-1,3-bis(5,5-dimethyl-1-glycidylhydantoin-3-yl)propane.

For preparation of the epoxy resin compositions according to the invention, preference is given to the use of a liquid or solid polyglycidyl ether or ester, especially a liquid or solid diglycidyl ether of bisphenol or a solid or liquid diglycidyl ester of a cycloaliphatic or aromatic dicarboxylic acid, or a cycloaliphatic epoxy resin. Mixtures of epoxy resins can also be used.

Suitable solid polyglycidyl ethers and esters are compounds having melting points above room temperature up to about 250°C. The melting points of the solid compounds are preferably in the range from 50 to 150°C. Such solid compounds are known and, in some cases, commercially available. It is also possible to use, as solid polyglycidyl ethers and esters, the advancement products obtained by pre-lengthening liquid polyglycidyl ethers and esters.

The epoxy resin compositions according to the invention comprise especially a liquid polyglycidyl ether or ester.

Special preference is given, as component A, to diglycidyl ethers of bisphenol A, diglycidyl ethers of bisphenol F, mixtures of a diglycidyl ether of bisphenol A and a diglycidyl ether of bisphenol F, epoxy urethanes, aliphatic epoxy resins such as trimethylolpropane triglycidyl ethers and also cycloaliphatic epoxy resins such as hexahydrophthalic acid diglycidyl ester.

The polymercaptopolyamines in accordance with the invention can advantageously be used in combination with other epoxy hardeners, especially the customary amine hardeners.

The invention accordingly relates further to a composition comprising
(A) an epoxy resin,
(B) a compound of formula Ia or Ib and
(C) a polyamine.

Examples of suitable polyamines C are aliphatic, cycloaliphatic, aromatic and heterocyclic amines, for example bis(4-aminophenyl)methane, aniline-formaldehyde resins, benzylamine, n-octylamine, propane-1,3-diamine, 2,2-dimethyl-1,3-propanediamine (neopentanediamine), hexamethylenediamine, diethylenetriamine, bis(3-aminopropyl)amine, N,N-bis(3-amino-propyl)methylamine, triethylenetetramine, tetraethylenepentamine, pentaethylenhexamine, 2,2,4-trimethylhexane-1,6-diamine, m-xylylenediamine, 1,2- and 1,4-diaminocyclohexane, bis(4-aminocyclohexyl)methane, bis(4-amino-3-methylcyclohexyl)methane, 2,2-bis(4-aminocyclohexyl)propane and 3-aminomethyl-3,5,5-trimethylcyclohexylamine (isophorone-diamine), polyaminoimidazolines and polyaminoamides, for example those derived from aliphatic polyamines and dimerised or trimerised fatty acids. Also suitable as amines (C) are the polyoxyalkyleneamines from Texaco known as Jeffamines[†], for example Jeffamine[†] EDR148, D230, D400 and T403.

Further suitable polyamines (C) are 1,14-diamino-4,11-dioxatetradecane, dipropylene-triamine, 2-methyl-1,5-pantanediamine, N,N'-dicyclohexyl-1,6-hexanediamine, N,N'-dimethyl-1,3-diaminopropane, N,N'-diethyl-1,3-diaminopropane, N,N-dimethyl-1,3-diaminopropane, secondary polyoxypropylene-di- and -triamines, 2,5-diamino-2,5-dimethylhexane, bis(amino-

methyl)tricyclopentadiene, m-aminobenzylamine, 1,8-diamino-p-menthane, bis(4-amino-3,5-dimethylcyclohexyl)methane, 1,3-bis(aminomethyl)cyclohexane, dipentylamine, bis(4-amino-3,5-diethylphenyl)methane, 3,5-diethyltoluene-2,4-diamine and 3,5-diethyltoluene-2,6-diamine.

As component A of the substance mixtures in accordance with the invention, preference is given to cycloaliphatic and aliphatic amines, especially the amines of formulae $R_5\text{-NH-}R_2$ and $E\text{-(NHR}_2\text{)}_{m+1}$ used for preparation of the polymercaptopolyamines according to the invention.

The ratio of amounts of components A and B and, where applicable, C in the compositions according to the invention can vary within wide limits. The optimum ratio is dependent upon, *inter alia*, the kind of amine, and can be readily determined by the person skilled in the art.

Component B and, where applicable, component C are preferably used in amounts such that the sum of the amine and mercaptan equivalents is from 0.5 to 2.0 equivalents, especially from 0.8 to 1.5 equivalents, and more especially from 0.9 to 1.2 equivalents, based on one epoxy equivalent.

The compositions according to the invention may optionally comprise accelerators, for example tertiary amines or imidazoles.

Furthermore, the curable mixtures may comprise tougheners, for example core/shell polymers or the elastomers or elastomer-containing graft polymers known to the person skilled in the art as rubber tougheners.

Suitable tougheners are described, for example, in EP-A-449 776.

In addition, the curable mixtures may comprise fillers, for example metal powder, wood flour, glass powder, glass beads, semi-metal and metal oxides, e.g. SiO_2 (Aerosils, quartz, quartz powder, fused silica powder), corundum and titanium oxide, semi-metal and metal nitrides, e.g. silicon nitride, boron nitride and aluminium nitride, semi-metal and metal carbides (SiC), metal carbonates (dolomite, chalk, CaCO_3), metal sulfates (barytes, gypsum), ground minerals and natural or synthetic minerals chiefly of the silicate series, e.g. zeolites (especially molecular sieves), talcum, mica, kaolin, wollastonite, bentonite and others.

In addition to the additives mentioned above, the curable mixtures may also comprise further customary additives, e.g. antioxidants, light stabilisers, plasticisers, dyes, pigments, thixotropic agents, toughness improvers, antifoams, antistatics, lubricants and mould-release agents.

The curing of the epoxy resin compositions according to the invention to form mouldings, coatings or the like is carried out in a manner customary in epoxy resin technology, for example as described in "Handbook of Epoxy Resins", 1967, by H. Lee and K. Neville.

Special mention should be made of the high reactivity of the polymercaptopolyamines according to the invention with respect to epoxy resins even at low temperatures (from -5°C to 25°C).

The curable mixtures exhibit only a slight tendency to carbonatisation (becoming cloudy). The cured products are distinguished by surprisingly high resistance to chemicals and resistance to weathering.

The invention relates further to the cross-linked products obtainable by curing a composition according to the invention.

The compositions according to the invention are excellently suitable as a coating composition, adhesive, bonding composition for composite materials or casting resin for the manufacture of mouldings.

Examples:

I. Preparation of compounds of formula I

a) General procedure for the preparation of polyepisulfides:

The polyepoxide of formula II is dissolved in an amount of solvent that is from 0.5 to 5 times the amount of the polyepoxide and is stirred, under nitrogen, with thiourea or alkali-metal or ammonium thiocyanate (0.8-1.2 equivalents of sulfur per epoxy equivalent) at 60-100°C until the epoxy content has fallen to nearly zero.

After separating off the by-products by means of filtration, extraction or phase separation, the polyepisulfide is isolated as a result of concentration by evaporating off the solvent.

b) General procedure for the preparation of polymercaptopolyamines:

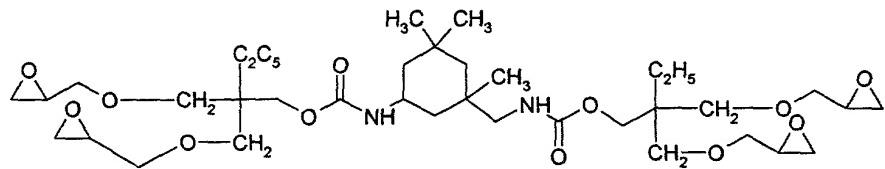
The polyepisulfide is dissolved in an amount of solvent that is from 0.5 to 5 times the amount of the polyepisulfide and, under nitrogen and with vigorous stirring, is combined with the amine, which likewise has been dissolved in an amount of solvent that is from 0.5 to 5 times the amount of the amine. The amount of amine is selected so that there are from 1 to 10 NH₂ groups for one episulfide group. After stirring at 60-100°C for from 0.2 to 3 hours, the solvent is distilled off under reduced pressure. To isolate the polymercapto-polyamine of formula I, the excess amine reagent is removed by means of vacuum distillation at elevated temperature.

In one embodiment of the invention, the excess amine is not removed and the mixture of the amine R₁-NH₂ and the polymercaptopolyamine of formula I is used as hardener for epoxy resins.

In accordance with the above-mentioned procedure, polymercaptopolyamines according to the invention (Examples I.1-I.19) are prepared from the following diamines R₁-NH₂ and epoxides of formula II:

BA:	n-butylamine
OA:	n-octylamine
CYA:	cyclohexylamine
BZA:	benzylamine
MBA:	methylbutylamine
DMDP:	N,N-dimethyl-1,3-diaminopropane
MDP:	N-methyl-1,3-diaminopropane
DACY:	1,2-diaminocyclohexane
AEP:	N-2-aminoethylpiperazine
DETA:	diethylenetriamine
IPD:	isophoronediamine
MXDA:	meta-xylynediamine
DYTEK-A:	1,5-diamino-2-methylpentane
NBDA:	isomeric mixture of 2,5- and 2,6-bis(aminomethyl)norbornane
EDA:	ethylenediamine

- epoxide 1: liquid diglycidyl ether of bisphenol A having an epoxy content of 5.25-5.4 eq./kg
epoxide 2: liquid mixture of diglycidyl ether of bisphenol A and diglycidyl ether of bisphenol F having an epoxy content of 5.5-5.8 eq./kg
epoxide 3: 1,4-bis(hydroxymethyl)cyclohexane diglycidyl ether
epoxide 4: epoxy phenol novolak having an epoxy content of 5.6-5.8 eq./kg
epoxide 5: diglycidyl ether of hydrogenated bisphenol A
epoxide 6: tetraglycidyl ether of formula



- epoxide 7: di(β -methylglycidyl) ether of bisphenol A
epoxide 8: trimethylolpropane triglycidyl ether
epoxide 9: hexahydrophthalic acid diglycidyl ester (epoxy content: 5.6-6.2 eq./kg)
epoxide 10: phenyl glycidyl ether

The reaction conditions and the properties of the final products are listed in Table 1.

Table 1:

Example	Starting products		molar ratio episulfide/ amine	T/°C	viscosity [mPa · s]	amine value [equivalents/kg]
	amine	epoxide				
I.1	DETA	epoxide 1	1 : 5	100	1900 ^{a)}	10.5
I.2	DETA	epoxide 1	1 : 5	100	>50 000	7.1
I.3	IPD	epoxide 1	1 : 5	100	5300 ^{a)}	7.6
I.4	MXDA	epoxide 1	1 : 5	60	2030 ^{a)}	9.6
I.5	MXDA	epoxide 1	1 : 5	60	>50 000	-
I.6	MXDA	epoxide 1	1 : 4	60	9000 ^{a)}	8.5
I.7	MXDA	epoxide 2	1 : 5	55	2200 ^{a)}	9.2
I.8	MXDA	epoxide 2	1 : 4	55	4400 ^{a)}	8.1
I.9	MXDA	epoxide 2	1 : 3	55	50 000 ^{a)}	7.6
I.10	IPD	epoxide 2	1 : 5	100	27 000 ^{a)}	7.8
I.11	IPD	epoxide 2	1 : 3	100	>50 000 ^{a)}	6.3
I.12	DETA	epoxide 2	1 : 5	100	2000 ^{a)}	-
I.13	DYTEK-A	epoxide 2	1 : 5	100	1600 ^{a)}	10.0
I.14	NBDA	epoxide 2	1 : 5	60	13 500 ^{a)}	8.4
I.15	EDA	epoxide 2	1 : 5	100	>50 000	-
I.16	MXDA	epoxide 3	1 : 5	60	300 ^{a)}	9.8
I.17	MXDA	epoxide 3	1 : 4	60	500 ^{a)}	8.8
I.18	IPD	epoxide 3	1 : 4	60	970 ^{a)}	-
I.19	DETA	epoxide 3	1 : 5	100	>50 000	-
I.20	BA	epoxide 2	1 : 10	77	>60 000	2.6
I.21	CYA	epoxide 2	1 : 10	100	>60 000	3.3
I.22	BZA	epoxide 2	1 : 10	100	>60 000	2.8
I.23	OA	epoxide 2	1 : 10	90	>60 000	
I.24	CYA	epoxide 4	1 : 10	100	>60 000	4.1
I.25	BZA	epoxide 4	1 : 10	100	>60 000	3.6
I.26	BA	epoxide 3	1 : 10	80	3000-7000	2.9
I.27	CYA	epoxide 3	1 : 10	100	>60 000	3.1
I.28	BZA	epoxide 3	1 : 10	100	10 200	3.0

Example	Starting products		molar ratio episulfide/ amine	T/°C	viscosity [mPa · s]	amine value [equivalents/kg]
	amine	epoxide				
I.29	OA	epoxide 3	1 : 10	100		
I.30	BA	epoxide 5	1 : 10	75	>128 000	2.15
I.31	MBA	epoxide 5	1 : 10	75	13 440	-
I.32	BA	epoxide 6	1 : 20	75	>128 000 ^{*)}	2.04
I.33	MBA	epoxide 6	1 : 20	60	12 800	-
I.34	IPD	epoxide 6	1 : 20	60	>128 000 ^{*)}	7.83
I.35	DMDP	epoxide 3	1 : 10	70	1400	7.42
I.36	MDP	epoxide 3	1 : 10	65	43 520	6.17
I.37	DACY	epoxide 3	1 : 5	65	840	10.71
I.38	AEP	epoxide 3	1 : 5	65	400	10.45
I.39	MBA	epoxide 3	1 : 2	67	1040	-
I.40	BA	epoxide 7	1 : 10	70	>128 000	3.10
I.41	DACY	epoxide 3	1 : 2	75	87 040	6.34
I.42	AEP	epoxide 3	1 : 2	77	11 520	6.72
I.43	MBA	epoxide 6	1 : 15	80	1160	-
I.44	MBA	epoxide 8	1 : 3	70	>128 000	-
I.45	IPD	epoxide	2 : 1	75	>128 000	2.83
		10				
I.46	BA	epoxide	1 : 5	78	3040	2.75
		10				

^{*)} mixture of amine R₁-NH₂ and polymercaptopolyamine; excess R₁-NH₂ not distilled off

^{**) practically a gel}

Application Examples

II.1 Polymercaptopolyamine as hardener for epoxy resins

100 g of a liquid diglycidyl ether of bisphenol A having an epoxy content of 5.25-5.4 eq./kg are mixed with 28 g of the polymercaptopolyamine of Example I.4 at 20°C. The mixture is applied to glass plates or steel plates using a doctor blade (thickness of layer: 0.2 mm) and fully cured for 10 days at 20°C.

For comparison purposes, 100 g of the same epoxy resin are fully cured using 20 g of a commercially available amine hardener (DETA) under the same conditions.

The fully cured coatings exhibit the properties listed in Table 2.

Table 2:

Example II.1	according to the invention (polymercaptopolyamine)	comparison (DETA)
viscosity (DIN 53018 T1/76) [mPa · s]	5600	8650
gel time according to TECAM at 20°C[min]	35	15
dust-dry time [h] at 20°C	2.0	> 30
at 5°C	2.5	> 30
exudation at 5°C	none	considerable
hardness according to Persoz (ISO 1552) [s] at 20°C		
after 1 day	358	340
after 1 week	383	365
after 1 month	394	355
hardness according to Persoz (ISO 1552) [s] at 5°C		
after 1 day	235	80
after 1 week	267	220
after 1 month	386	250

II.2 Polymercaptopolyamine as co-hardener in admixture with other polyamine hardeners

100 g of a liquid diglycidyl ether of bisphenol A having an epoxy content of 5.25-5.4 eq./kg are mixed with 17 g of a commercially available amine hardener (DETA) and 4.2 g of the polymercaptopolyamine of Example I.5. The mixture is processed and fully cured as described in Example II.1.

For comparison purposes, the above-mentioned mixture without the addition of the polymercaptopolyamine is fully cured under the same conditions.

The fully cured coatings exhibit the properties listed in Table 3.

Table 3:

Example II.2	according to the invention (polymercaptopolyamine + DETA)	comparison (DETA)
gel time according to TECAM at 20°C [min]	19	15
dust-dry time [h] at 20°C/65 % rel. humidity	4	>30
full hardening time [h] at 20°C/65 % rel. humidity	13	>30
hardness according to Persoz (ISO 1552) [s]		
after 1 d at 20°C	310	195
after 7 d at 20°C	349	229
after 1 d at 5°C	73 (tacky)	24 (tacky)
after 7 d at 5°C	148 (tacky)	39 (tacky)

II.3 Polymercaptopolyamine as hardener for epoxy resins

The polymercaptopolyamine prepared according to Example I.26 is mixed with the epoxy resins and further additives listed in Table 4 and fully cured.

The properties of the mixtures and of the cured products are likewise listed in Table 4.

Table 4:

Example	II.3.1	II.3.2	II.3.3
epoxide 9 [g]	41	37.4	
epoxide 8 [g]			43.32
epoxide 6 [g]			
polymercaptopolyamine [g]	29	32.6	26.68
TiO ₂ (Kronos 2310) [g]	30	30	30
flow improver BYK 300 [g]	0.14	0.14	0.14
methyl ethyl Ketone [g]			8.8
viscosity (Epprecht viscosimeter) at 20°C			
of freshly prepared mixture [mPa · s]	5760	3520	2720
after 60 min [mPa · s]	>128 000	>128 000	76 800
curing for 12 days at RT			
hardness according to Persoz [s]	20	24	63
impact deformation ¹⁾ (direct impact) [cm · kg]	>160	>30	>60
impact deformation (reverse impact) [cm · kg]	>80	>20	>20
Erichsen indentation test ²⁾ [mm]	10.5	8.9	9.3
acetone test	2	2	1-2
curing for 30 min at 80°C and 12 d at RT			
hardness according to Persoz [s]	20	26	113
impact deformation ¹⁾ (direct impact) [cm · kg]	>160	>30	>60
impact deformation (reverse impact) [cm · kg]	>80	>10	>30
Erichsen indentation test ²⁾ [mm]	10.6	9.1	9.8
acetone test ³⁾	2	2	1

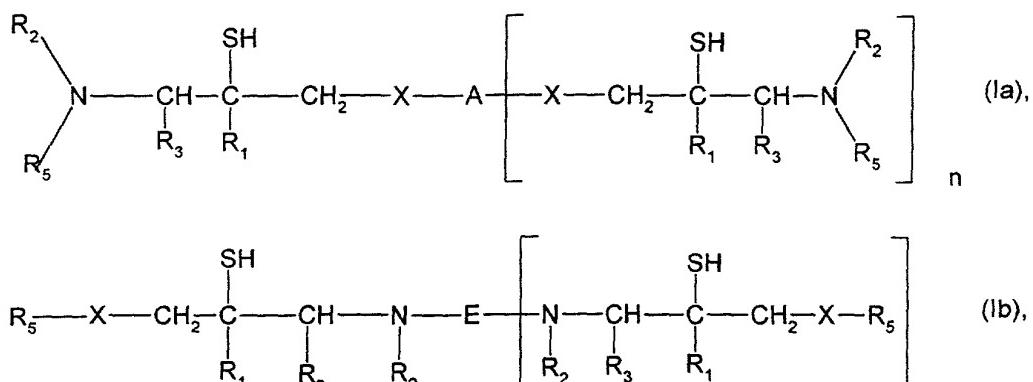
¹⁾ The impact deformation (direct impact) is determined by dropping a punch having a weight of 2 kg, on the underside of which there is a sphere 20 mm in diameter, directly onto the coated surface from a certain height, underside down. The value given is the product of the weight of the punch in kg and the maximum test height in cm at which no damage to the coating can be found. In impact deformation (reverse impact) the punch is dropped onto the face remote from the coating.

²⁾ according to DIN 53156

³⁾ according to DIN 53320. The specimen is held in acetone for 1 min. The result is assessed according to the following five-point scale: 0 = unchanged; 1 = not scratchable with a finger nail but drags; 2 = difficult to scratch; cotton wool may be stained; 3 = softened, readily scratched; 4 = starting to come away or dissolve away; 5 = dissolved away completely.

Patent claims

1. A compound of formula Ia or Ib,



wherein A is an (n + 1)-valent aliphatic, cycloaliphatic, araliphatic or aromatic radical and n is an integer from 0 to 5,

E is an (m + 1)-valent aliphatic, cycloaliphatic, araliphatic or aromatic radical and m is an integer from 0 to 3,

X is -O-, -COO- or -CHR₄-, with R₄ and R₃ together forming an ethylene group,

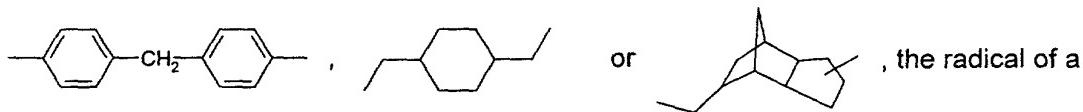
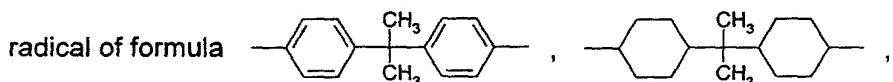
R₁ and R₂ are, each independently of the other, hydrogen or methyl,

R₃ is hydrogen, or R₃ and R₄ together form an ethylene group,

and R₅ is a monovalent aliphatic, cycloaliphatic, araliphatic or aromatic radical.

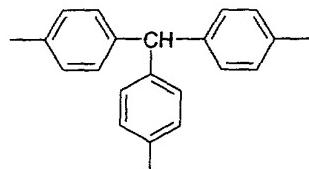
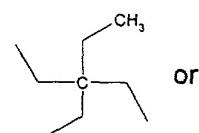
2. A compound of formula Ia according to claim 1, wherein X is -O- and A is a bivalent radical of a bisphenol or of a cycloaliphatic diol, the radical of a phenol novolak or cresol novolak, the bi- to tetra-valent radical of an isocyanate/polyol adduct or the tri- to hexa-valent radical of a tri- to hexa-functional aliphatic polyol.

3. A compound of formula Ia according to claim 1, wherein X is -O- and A is a bivalent

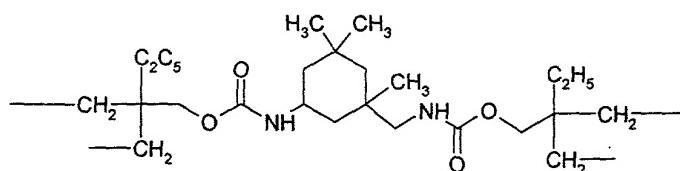


, the radical of a

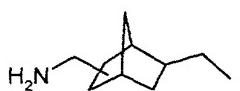
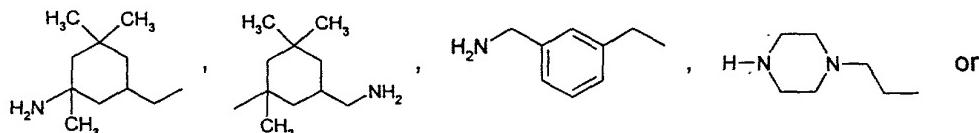
phenol novolak or cresol novolak, a trivalent radical of formula



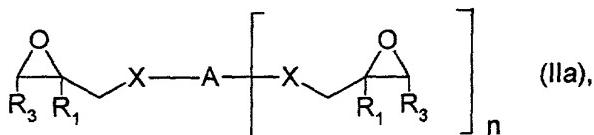
or the tetravalent radical of formula



4. A compound of formula Ia or Ib according to claim 1, wherein R₅ is C₁-C₂₀alkyl, C₅-C₁₂-cycloalkyl, C₆-C₁₀aryl or C₇-C₁₂aralkyl, each of which is unsubstituted or substituted by one or more amino groups, hydroxyl groups, C₁-C₈alkoxy groups or halogen atoms.
5. A compound of formula Ia or Ib according to claim 1, wherein R₅ is C₂-C₁₀alkyl, C₂-C₁₀aminoalkyl, phenyl, benzyl, cyclohexyl or a radical of formula H₂N-Z-CH₂-NH-, wherein Z is a bivalent cycloaliphatic, araliphatic or aromatic radical or a radical of formula -(CH₂CH₂NH)_k-CH₂-, wherein k is 2 or 3.
6. A compound of formula Ia or Ib according to claim 1, wherein R₁ is n-butyl, n-octyl, cyclohexyl, benzyl, 2-aminoethyl, 4-(aminomethyl)pentyl, 5-amino-2-methylpentyl, 3-dimethylaminopropyl, 3-methylaminopropyl, 4-aminocyclohexyl or a radical of formula -CH₂CH₂NHCH₂CH₂NH₂,

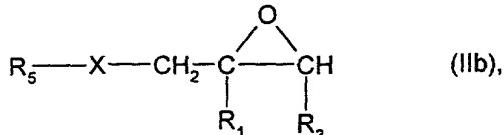


7. A compound of formula Ia or Ib according to claim 1, wherein X is O- and R₁ and R₃ are hydrogen.
8. A process for the preparation of a compound of formula Ia according to claim 1 by reacting a compound of formula IIa



wherein A, X, R₁, R₃ and n are as defined in claim 1,
with thiourea or a thiocyanate and subsequently reacting the resulting episulfide with an
amine of formula R₅-NH-R₂ wherein R₅ and R₂ are as defined in claim 1.

9. A process for the preparation of a compound of formula Ib according to claim 1 by reacting a compound of formula IIb



wherein X, R₁, R₃ and R₅ are as defined in claim 1,
with thiourea or a thiocyanate and subsequently reacting the resulting episulfide with a
polyamine of formula E-(NHR₂)_{m+1} wherein E, R₂ and m are as defined in claim 1.

10. A composition comprising

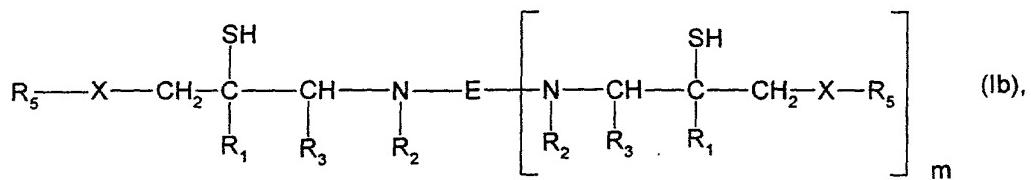
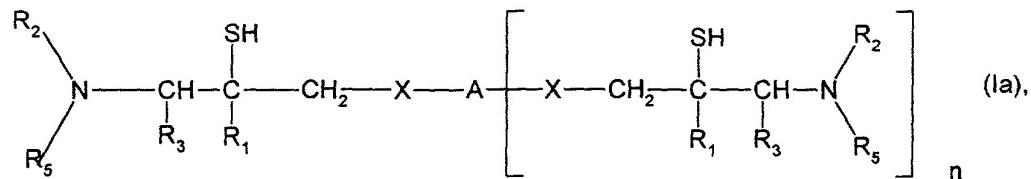
(A) an epoxy resin and
(B) a compound of formula Ia or Ib according to claim 1.

11. A composition according to claim 10 comprising, in addition,
(C) a polyamine.

12. A composition according to either claim 10 or claim 11 comprising component B and, where applicable, component C in such amounts that the sum of the amine and mercaptan equivalents is from 0.5 to 2.0 equivalents, based on one epoxy equivalent.
13. A cross-linked product obtainable by curing a composition according to claim 10.
14. Use of a composition according to claim 10 as coating composition, adhesive, bonding composition for composite materials or casting resin for the manufacture of mouldings.

Abstract

Compounds of formula Ia or Ib



wherein A is an (n + 1)-valent aliphatic, cycloaliphatic, araliphatic or aromatic radical and n is an integer from 0 to 5,

E is an (m + 1)-valent aliphatic, cycloaliphatic, araliphatic or aromatic radical and m is an integer from 0 to 3,

X is -O-, -COO- or -CHR₄-, with R₄ and R₃ together forming an ethylene group,

R₁ and R₂ are, each independently of the other, hydrogen or methyl,

R₃ is hydrogen, or R₃ and R₄ together form an ethylene group,

and R₅ is a monovalent aliphatic, cycloaliphatic, araliphatic or aromatic radical,

are highly reactive curing agents for epoxy resins and yield cured products having improved resistance to chemicals.

**UTILITY DECLARATION
AND POWER OF ATTORNEY
Utility Application**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Amine Hardener for Epoxy Resins

the specification of which

- is attached hereto OR
- was filed on _____ as United States Application Serial No. ____ OR
- was filed on 20 July 2000 as PCT International Application No. PCT/EP 00/06931
- and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Date of Filing (day/month/year)	Priority Claimed	
			Yes	No
1389/99	Switzerland	28/07/1999	<input checked="" type="checkbox"/>	<input type="checkbox"/>

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (day/month/year)

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Number	Parent Filing Date (day/month/year)	Status-Patented, Pending or Abandoned

POWER OF ATTORNEY: As a named inventor, I hereby appoint as my attorneys and/or agents, with full power of substitution and revocation, to prosecute this application and transact all business in the United States Patent and Trademark Office, and in countries other than the United States, and to do all things necessary or appropriate therefor before any competent International Authorities in connection with any international patent application(s) corresponding to the above-identified invention application, all of the registered practitioners identified by Customer Number 22249:



Please direct all inquiries to Kristin H. Neuman, Esq., at the above Customer Number. Ms. Neuman's direct line is (914) 681-8851 ext. 4603.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18, United States Code, § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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